The occupational domain and initial earnings of recent Irish graduates

Is a science and technology degree good for you?

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Abstract

Purpose – The purpose of this paper is to examine the hypothesis that those with a university qualification in science and technology (S&T) enjoy favourable labour market outcomes.

Design/methodology/approach – Analysis is based on individual-level data detailing the labour market experiences of Irish university graduates upon entering employment. A Gini-Hirschman index is used to estimate the number of occupational options open to graduates of a particular educational background. Additionally, an ordered probit model of earnings is estimated, which is controlling other factors, measures the effect of S&T education on the distribution of earnings.

Findings – S&T graduates have a wider occupational domain. Additionally, tabulations indicate that on the whole they tend to earn more. Application of an ordered probit model controlling for other factors suggests that engineering graduates enjoy a clear earnings advantage; however the opposite appears to be the case for science graduates.

Originality/value – The paper presents original insights into the occupational outcomes of Irish technical graduates. The relatively lower earnings of science graduates bring into question the current preoccupation with the supply side and suggest that a closer look at the demand for such skills may be warranted. These findings may be interesting for policy seeking to influence skill structure and for further studies investigating the returns to components of skill.

Keywords Employment, Education, Pay differentials, Training, Ireland

Paper type Research paper

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1. Introduction

The much-heralded move to the knowledge-based economy places new demands on labour markets and may favour specific skills distributions (OECD, 2000). Motivated by this observation, recent years have seen a renewed international policy concern with matters relating to the supply of human resources for science and technology (HRST; Aho *et al.*, 2006; Commission of the European Communities (CEC), 2007). For example, the EU's Lisbon Strategy for growth and employment calls for increasing the share of EU GDP devoted to research to 3 per cent by 2010; in terms of human resources, an extra half a million researchers (or 1.2 million research-related personnel) would be needed to reach that goal (Gago *et al.*, 2004, p. 1).

This international policy concern has resonated strongly in Ireland and not without good reason. In the course of the past two decades, the Irish economy has experienced rapid growth, much of it in sectors that capitalise on recent technical advances and present ample opportunities for further technical change[1]. Recently, increasing the country's capacity to innovate is a key public policy priority (Irish Government, 1999; Kane, 1999; Forfás, 2004a). In such a context, the generation and profitable allocation of HRST is a major concern. Numerous policy-oriented documents have stressed the need for the development of Ireland's HRST (Healy, 1983; DETE, 1997; Higher Education Authority (HEA), 2002; Expert Group on Future Skills Needs, 2004; Enterprise Strategy Group (ESG), 2004; Forfás, 2004a). Responses have included key interventions in education, particularly at the third level (Whickham and Boucher, 2004).

Ireland currently stands in a priviliged position among its EU counterparts in terms of available HRST and (what is widely perceived as) an associated surge of high-value adding foreign (and increasingly domestic too) investment. It is no wonder then that the prospect of skills shortages[2] is greeted with a sense of alarm. Despite an intense policy interest in matters surrounding the supply of HRST, information on the career outcomes of S&T education is still hard to come by. Such information would be valuable to innovation-minded policy as it impacts directly on the overall attractiveness of S&T education.

There are good reasons to expect that Irish S&T graduates may enjoy advantageous occupational outcomes. A sizeable body of work has lent credence to what is known as the "skills bias hypothesis" (Nelson and Phelps, 1966; Juhn *et al.*, 1993; Acemoglu, 2002; CEC, 2005). It postulates that as technology advances and proliferates throughout the economy, labour market rewards are biased in favour of skilled workers. Moreover, in some cases the extent of this bias has been found to be related to the type of skills possessed, a "skill component". In the case of Ireland, the relatively recent economic shift has placed specific demands on the labour market that may favour S&T graduates.

The present paper investigates whether the current state of the labour market in Ireland favours those with a qualification in science and technology (S&T)[3]. Analysis is based on individual-level data detailing the labour market experiences of Irish university graduates upon entering employment. Calculations using a Gini-Hirschman index indicate that S&T graduates have a wider occupational domain. Higher specialisation narrows down a graduate's occupational domain for both S&T and other graduates. Additionally, tabulations indicate that on the whole S&T graduates tend to earn more. However, application of an ordered probit model controlling for other factors (gender, age, years of schooling, a proxy of ability, Dublin-based employment, geographic mobility and sectoral dummies) shows that, engineering graduates enjoy a clear earnings advantage, while the opposite is true for science graduates.

2. Background

2.1 Rationale

Whilst there is a case to be made for education in almost any setting, the private returns to education are greater in a technologically advanced society. Acemoglu (2002) argues that for most of the past century, the societal influence of technical change has been skill-biased; there are strong indications in literature of an association between technological development and returns to years of schooling (see Berman *et al.*, 1998; Psacharopoulos and Patrinos, 2002 and references therein).

Additionally, structural change may result in increased returns to specific components of skill (e.g. the content of education) which are not related with investment in years of schooling (Juhn *et al.*, 1993). Explanations for this empirical result are varied. Temporary demand/supply mismatches, increased ability to learn and adapt to structural disequilibria as well as technology-induced occupational domain variability have been proposed (Schultz, 1975; Berman *et al.*, 1998; Acemoglu, 2002; Piva *et al.*, 2005, 2006). Acemoglu (2002) points to evidence showing that those with the "right" skills have experienced the greatest increases in welfare. What skills may be the "right" ones at any given point is, of course, determined by the needs of industry.

Economic growth in Ireland has been most profound within what are now often referred to as the country's two main sectoral "clusters"; these include FDI-based, export-driven companies that produce or make heavy use of information and communication technologies (ICT) and biotechnology (Green, 2000; Pontikakis *et al.*, 2006). HRST demand in these clusters has been fuelled by the need to staff newly diffused machinery and processes as well as by the build up of substantial research and development (R&D) capabilities.

Policy makers see an uninterrupted HRST supply system as an important condition for the sustainability[4] and further development of Ireland's "knowledge-based" economy (HEA, 2002) and hence the country's international competitiveness (ESG, 2004; Forfás, 2004a). At the same time, there is a conscious encouragement of continuous "up-skilling", particularly of those skills which relate directly to industrial R&D.

Third-level education in Ireland is dispensed by universities, institutes of technology and colleges. The Irish education system has undergone a substantial reorganisation in recent years. The role of institutes of technology has been promoted and their capacity to produce pre-degree level S&T graduates has been increased. A single coordinator body for all third-level institutions does not exist, with the HEA being directly responsible only for universities[5]. While historically Irish third-level education was centred on the humanities, in recent years educational policy has become more pragmatic. Recently, the main education policy preoccupations are the needs of the economy and a further increase in participation (Rhodes *et al.*, 2003).

The re-orientation of the education system combined with favourable demographics have resulted in increased numbers of S&T graduates (Whickham and Boucher, 2004). Ireland possesses the greatest percentage of such graduates among its EU partners[6], while demand for their skills is strong and continuing. Indeed, Sexton *et al.* (2004) expect this demand trend to continue well into the next decade, to the point of making labour shortages in key S&T skills probable. Sexton *et al.* (2004) blame these shortages partly on waning student interest for S&T subjects and partly on the very limits imposed by demographics.

Given the combination of the centrality that innovative industries now occupy in the Irish economic landscape and the present and forecasted skill shortages, the possibility that a technical education might lead to privileged occupational outcomes does not appear remote.

2.2 The data

Empirical analysis is based on data from the HEA's First Destinations of Award Recipients Survey (henceforth FDAR). FDAR is a survey of graduate destinations that has been performed every April since 1981. Participating academic institutions post short questionnaires to graduates who completed their studies on the previous academic year. The intended sample is identical to the total population of new third-level graduates for that year. The survey includes a wide range of questions and has traditionally had high response rates (above 70 per cent). Despite the dataset's long history, relative representativeness and high response rates, it has been a largely underutilised resource. A notable exception is Lydon's (1999) historical analysis of FDAR data. Lydon (1999) found that throughout the 1990s and in the backdrop or rapid economic growth, professional prospects (rates of employment and initial earnings) for recent graduates improved considerably.

Three individual-level samples for the years 2001, 2002 and 2003 were obtained. The survey response rates for 2001, 2002 and 2003, respectively, were 73.5, 71.6 and 67.5 per cent.[7] It is worth remembering that these are percentages of the population total graduating each year. A breakdown of first destinations for these years is shown in Figure 1. At first glance, one may observe that close to 60 per cent of graduates were employed, of which one-third were in S&T employment. Notable is also the low incidence of unemployment, less than 4 per cent in the years in question. Historical studies have shown that unemployment became a less likely destination, with the numbers of unemployed graduates falling steadily throughout the 1990s (Lydon, 1999, p. 236; Gash and O'Connell, 2000, p. 4). This was partly owed to increases in the numbers

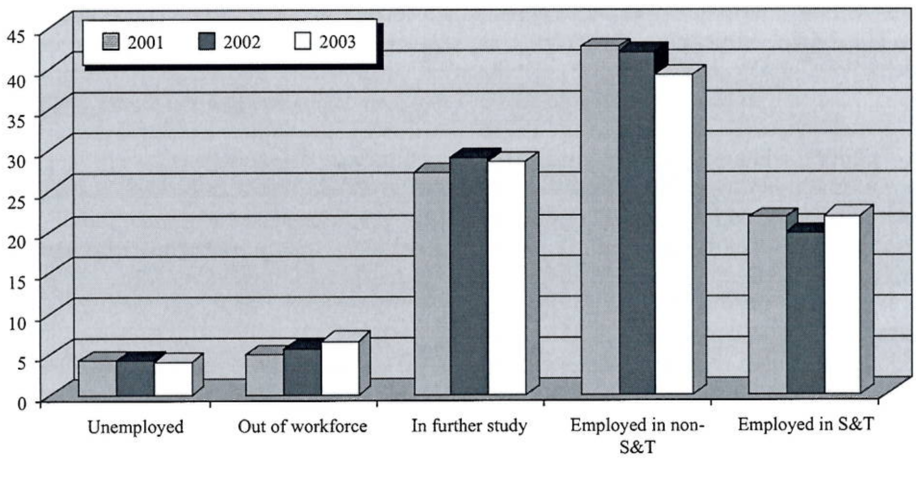

Figure 1.
Irish graduates by destination (percentages per year)

of those in employment and partly to the heightened popularity of postgraduate study. In 2003, just over a quarter of graduates opted to continue their studies.

A detailed outline of the variables used in the study can be found in Appendix 1, along with descriptive statistics in Appendix 2. In line with international practice, the OECD's (1995) Canberra Manual was consulted regarding the classification of S&T versus non-S&T degrees (variable stedu) and employment (variable stemp). S&T educational classifications are classified according to faculty of study and included the following: Science; Medicine, Dentistry and Paramedical Studies; Engineering; Agriculture; Veterinary Medicine; Architecture; Food Science and Technology. The OECD (1995) also proposes using the International Standard for Classifications in Education (ISCED) for assessing the relevance of an educational qualification to research-oriented occupations. Accordingly, the different qualification types awarded by the various third-level institutions were coded according to ISCED 5A (research preparatory) and ISCED 6 (research degrees) classifications (variable isced) (UNESCO, 1997). Finally, industrial sector and geographic location dummies were coded according to Eurostat's Nomenclature statistique des activités économiques dans la Communauté européenne [NACE (Statistical Classification of Economic Activities in the European Community)] and NUTS3 specifications, respectively.

3. The occupational domain of graduates

A stated aim of tertiary education is to prepare individuals for the workplace. However, the extent and relevance of vocational content to economic needs varies substantially from one degree to another. On one side of the spectrum, there are degrees (such as medicine) which have a rather narrow scope of occupational outcomes and on the opposite side degrees (for example, in English) with a much broader occupational reach. Therefore, certain university degrees bestow their graduates with a wider occupational domain than do others.

Relative statements such as the above are not very meaningful unless one can accurately define what is meant by "degree" and "occupation". Ideally, one should be in a position to define "degree" as an integer of a set of educational classifications. Likewise, "occupation" should refer to a unit belonging to a set of professional careers. This is not an easy task, since individual educational backgrounds and professional occupations are neither discrete nor equivalent units of analysis. There is invariably overlap in the educational content of many otherwise distinct educational qualifications and the same is true of the vocational content of many occupations. Additionally, continuing occupational specialisation may mean that what one thought to be a single occupation some time ago, now actually represents numerous separate professions. Inevitably then, a measure of the occupational domain carries the assumption that these overlaps are not significant and that on average they cancel themselves out.

If one possesses adequate information on the educational background of individuals and their subsequent occupations, one should in principle be able to measure the number of occupations corresponding to a particular educational background. This can be illustrated diagrammatically. A graduate with education i has an occupational domain spanning (one would hope) one or more occupations j. For each education i, there is a concomitant occupation or set of occupations, so for instance education i_3 opens up employment opportunities in occupations $j_1, j_2, j_3, \ldots, j_9$ (Figure 2). Conversely, education i_9 provides the possibility of employment in one of occupations j_{16}, j_{17} and j_{18}.

A few innocuous generalisations may be made at this point, serving to underline the advantages of a wide occupational domain. A wide occupational domain is an attractive career attribute not least because it signifies a greater choice of jobs and therefore minimises the probability of prolonged unemployment spells. Although employment opportunities are bound to be non-uniform across occupations, on the whole, a greater choice of professions should translate to a greater number of potential jobs. Graduates with a wide occupational domain possess skills that are needed across a range of professions, in some cases even pervading sectors. It is reasonable to expect that such skills are likely to be in demand even in periods of rapid structural change. Cyclical factors aside, a wide occupational domain is possibly the closest one can get to a predictor of career-long job security.

Contrarily, a narrow occupational domain may be the consequence of specialisation. Specialisation presents both demand- and supply-side barriers to greater occupational choice. It is perhaps a moot point that the skills of a highly specialised individual are unlikely to be required in a great number of professions. At the same time though, individuals invest in specialisation, motivated by expectations of high earnings (Becker, 1964). Professions that deviate from the (expensive) specialisation path imply a high switching cost for the worker.

Education is the most obvious source of specialisation. The higher the level of an educational qualification the greater the investment the individual has made to developing a particular bundle of skills. Indeed, Borghans *et al.* (1997) in their analysis of the Irish labour market found that the higher the level of a graduate's tertiary award, the narrower their choice of occupations after graduation. In the workplace too, the value of non-transferable occupation-specific skills increases as a function of

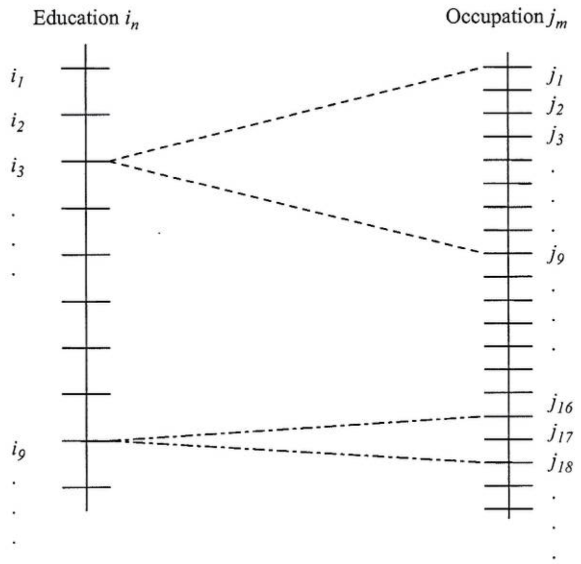

Figure 2.
A graphical representation of occupational domain

prolonged engagement in one profession. Arguably then, a graduate's occupational domain is widest just after graduation.

Hence, it would be opportune to measure the extent of the occupational domain at that time; one can plausibly assume specialisation to be wholly owed to education rather than on-the-job learning.

The occupational domain or the switching opportunities of a graduate with education i can be measured using a Gini-Hirschman dispersion index, as used previously in this context by Borghans *et al.* (1997). In calculating the index, one may begin with estimating the fraction of graduates with education i who subsequently obtained employment in occupation j (f_{ij}). The sum of these fractions for the whole set of education backgrounds i_n would then be equal to 1. The sum of the squares of those fractions (f_{ij}) would yield a measure of the prevalence of the particular educational background i among the whole set of occupations j_m. This can also be thought of as the probability that two persons with education i are to be found within occupation j, which is:

$$P_i = \sum f_{ij}^2 \qquad (3.1)$$

For an m number of occupations this probability equals 1 if everyone is in the same occupation j. If however, educational backgrounds are spread equally among occupations then $P_i = 1/m$. A Gini-Hirschman index of an individual's occupational domain can then be given by:

$$K_i = \frac{1}{P_i} \qquad (3.2)$$

The value of K_i can be interpreted[8] either as the extent of the occupational domain or the maximum number of occupations corresponding to an individual of a particular educational background. Table I presents the results of applying (3.1) and (3.2) on the FDAR dataset[9].

Calculations show that in the three-year period, graduates from the Faculties of Science, Arts Social Sciences and Humanities, as well as Engineering had the greatest occupational choice. By contrast, Medicine, Veterinary Medicine, Architecture and Law alumni had a rather more constrained set of professional options. Table I(b) demonstrates that, collectively, S&T (as opposed to non-S&T) graduates had a considerably wider range of occupations to choose from. No discernible variation patterns are present within the period under consideration. Table I(c) shows that increased specialisation is associated with a narrower occupational domain. This particular observation is in agreement with the findings of Borghans *et al.* (1997). There is a sharp difference between S&T and non-S&T graduates who were holders of a research preparatory degree (ISCED 5A: bachelors and masters); the former appear to enjoy a substantially broader occupational domain. Interestingly, though, no substantial differences exist in the occupational domain of S&T and other research degree holders (ISCED 6: MPhil and PhD).

4. Initial earnings

4.1 Tabulations of earnings by education

Demand for S&T skills may also be reflected in the initial salaries of young scientists and technologists. The presence of a positive skew in the initial earnings of S&T graduates appears plausible given the evidence of demand for S&T skills across a

Table I.
Extent of the occupational domain (maximum number of occupations)

	2001	2002	2003	Period average
(a) per HEA faculty				
HEA faculty				
Arts, Social Sciences and Humanities	21.4	22.6	15.9	19.9
Science	34.6	41.7	34.3	36.8
Commerce and Business Studies	15.3	17.2	13.1	15.2
Medicine, Dentistry and Paramedical Studies	4.3	5.3	4	4.5
Engineering	17.1	22.7	7.8	19.2
Law	10.1	8.4	10.7	9.7
Agriculture	10.7	13.3	12.7	12.2
Veterinary Medicine	1.2	1	1	1
Architecture	1.8	2.7	4	3.4
Food Science and Technology	11.2	10.6	13.2	11.6
(b) S&T versus non-S&T graduates				
Qualification type				
Non-S&T	28.8	30.8	24.2	27.9
S&T	45.7	52.2	37.0	44.9
(c) Research graduates				
Non-S&T qualifications				
ISCED 5A (research preparatory): bachelors degree/post-graduate diploma (PGD)/masters degree taught and qualifier	28.3	30.4	23.9	27.5
ISCED 6 (research degrees): MPhil/PhD	10.7	6.8	10	9.1
S&T qualifications				
ISCED 5A (research preparatory): bachelors degree/PGD/masters degree taught and qualifier	44.4	51.5	35.9	43.9
ISCED 6 (research degrees): MPhil/PhD	11	14.7	9.7	11.8

Notes: Author's calculations; highlighted faculties classified as S&T (OECD, 1995)

relatively large number of occupations. At the same time though, it is possible that the recent drive to increase the supply of such graduates may have dampened any positive bias to the S&T skill component.

The FDAR Survey requires graduates in employment to state their earnings by selecting one of eight annual salary bands. Since many careers in science and engineering begin with periods of low-paid training, the initial salaries of many S&T graduates may underestimate the lifelong profitability of their professions. This is worth noting, as it signals that any estimates of an S&T earnings advantage based on the FDAR data are probably conservative.

A first indication as to the presence of a positive bias or "earnings advantage" for S&T graduates can be sought by observing their relative presence in high and low wage bands. Figure 3 shows the proportions of graduates with S&T studies in respective salary bands on April after graduation. A quick glance at the data shows that S&T graduates account for a greater percentage of those entering employment on a higher wage.

A further indication of an S&T advantage can be obtained by observing the distribution of their earnings and comparing it against that of other graduates. However, comparisons of earnings distributions among sub-population groups that are themselves unequally distributed are hardly intuitive. Rather, a simple measure of the

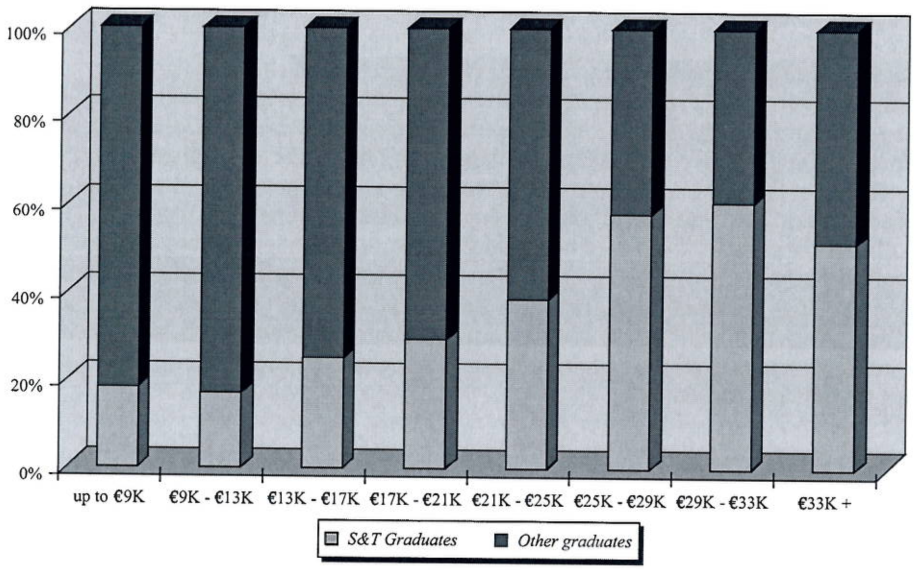

Figure 3. Proportions of S&T graduates per salary band (2001-2003 average)

relative earnings advantage (Δ) enjoyed by a specific set of graduates, in each salary band, can be estimated by:

$$\Delta\% = \frac{\text{percentage}_{\text{grads}} - \text{percentage}_{\text{other}}}{\text{percentage}_{\text{total}}} \quad (4.1)$$

In the present case, the relative advantage of a particular S&T education would manifest itself in negative values for Δ in lower wage bands and positive values in higher wage bands. Likewise, if S&T graduates were found to be at a relative disadvantage, Δ would be negative in higher wage bands and positive at lower wages bands.

Table II presents the distribution of S&T graduate earnings and their relative advantage in each wage band. It is immediately obvious that S&T graduates are rather more densely represented in higher wage bands (both absolutely and relative to other graduates) while being relatively underrepresented in lower bands. On the whole, their relative earnings advantage Δ is substantial, topping 102 per cent (salary band €29K-€33K).

Wage band	S&T grads	Other grads	Total	Δ
Up to €9K	1.6	5.8	4.2	− 100.00
€9K-€13K	1.9	6.5	4.7	− 97.87
€13K-€17K	6.5	12.6	10.2	− 59.80
€17K-€21K	12.2	21.9	18.2	− 53.30
€21K-€25K	19.7	23.6	22.1	− 17.65
€25K-€29K	22.6	12.1	16.2	64.81
€29K-€33K	18.7	6.9	11.5	102.61
€33K +	16.7	10.5	12.9	48.06

Notes: Author's calculations; highlighted faculties classified as S&T (OECD, 1995)

Table II. Distribution of earnings (FDAR 2003)

The above should not come as a surprise though, as the S&T classification (OECD, 1995) adopted here includes education paths that traditionally lead to highly paid (as well as occupationally narrow and heavily regulated) employment, such as degrees in medicine and architecture. There is arguably greater value in disaggregating degrees by faculty of study and observing the distribution of earnings therein. (Table III). Of greatest interest would be any observed advantage in the first salaries of graduates from the Faculties of Science and Engineering, given their importance for the knowledge-based economy and the central position they enjoy in the Irish policy debate.

Indeed, graduates from the Faculty of Engineering are overall more likely to be on a higher salary than either Arts, Commerce or Law graduates. However, graduates from the Faculties of Science, Agriculture and Food Science only possess a marginal earnings advantage (if at all) compared to graduates from non-S&T faculties. On the whole, graduates from the Faculties of Medicine, Veterinary Medicine and Architecture are the highest earners.

4.2 Econometric analysis

Observing the above one wonders whether the overall majority presence of S&T graduates in higher wage bands is really due to their skill component. This question is all the more reasonable when one considers that S&T graduates tend to study longer for their degrees. The manifested earnings advantage could also be in part due to reasons other than their formal training. Could it be, for example, that some students are more likely to study S&T and thence achieve higher salaries, not because of the type of skills they posses, but because of some other characteristic? In order to establish whether S&T training does indeed have an effect on the distribution of initial earnings, other factors known to influence wages need to be taken into account. Becker's (1964) and Mincer's (1974) seminal work specified an individual's earnings as a function of their investment in human capital, on-the-job experience and training, signals of their "ability" (e.g. credentials) as well as factors that become pertinent in the presence of labour market imperfections (e.g. discrimination) such as a person's gender, ethnicity and socioeconomic background.

Ryan's (2001) comprehensive cross-country review of empirical literature on the subject confirms that gender and ethnicity in particular are major sources of occupational disadvantage. At the same time, non-uniform labour demand across industrial sectors and geographic localities may account for varying wages. It is also conceivable that among individuals with the same characteristics, those who are readily willing to relocate may be able to secure better salaries. Additionally, previous Irish-specific work has shown that jobs based in Dublin enjoy a significant wage premium (Callan and Harmon, 1999; Denny and Harmon, 2000). The substantial growth of R&D-related employment in Ireland's (sectorally defined) innovative clusters[10], as well as the continuous increase in government funding reserved for research (Forfás, 2004b, p. 2) may positively predispose the initial earnings of S&T graduates and indeed those with a research-oriented qualification (ISCED 6). Using data from the UK, Tomlinson (1999) found that the analytical skills of S&T graduates are increasingly sought after by service sector firms too; the wide occupational domain enjoyed by such graduates indicates that the same may be true for Ireland.

An econometric model controlling for the above factors should be able to distinguish the effect of a S&T education on initial earnings. The FDAR Survey scales

Wage band	Up to €9K	€9K-€13K	€13K-€17K	€17K-€21K	€21K-€25K	€25K-€29K	€29K-€33K	€33K +
Arts, Social Sciences and Humanities	9.23	8.19	13.60	18.61	17.27	11.27	8.88	12.95
Δ (Arts, Social Sciences and Humanities)	170.20	103.68	47.08	3.51	−31.02	−43.38	−32.12	0.22
Science	2.60	3.32	11.21	18.83	25.38	17.49	9.24	11.93
Δ (Science)	−45.74	−35.94	11.58	4.43	17.95	9.59	−23.29	−9.31
Commerce and Business Studies	2.25	4.24	11.43	25.35	29.94	13.32	5.19	8.28
Δ (Commerce and Business Studies)	−66.32	−14.98	16.76	56.27	50.68	−25.20	−77.86	−51.13
Medicine, Dentistry and Paramedical Studies	0.40		0.40	0.80	3.18	14.51	49.50	31.21
Δ (Medicine, Dentistry and Paramedical Studies)	−97.84	−108.05	−103.85	−103.32	−92.48	−11.21	358.42	152.72
Engineering	0.82	1.10	3.84	11.66	22.36	32.37	13.44	14.40
Δ (Engineering)	−90.18	−86.16	−69.98	−40.14	1.45	112.02	19.32	12.74
Law	9.09	18.18	15.45	20.00	23.64	6.36	0.91	6.36
Δ (Law)	117.99	288.22	52.03	10.28	7.19	−61.71	−93.60	−51.64
Agriculture	4.41	2.94	8.82	16.18	20.59	26.47	5.88	14.71
Δ (Agriculture)	4.91	−38.35	−13.82	−11.05	−6.80	64.12	−49.20	13.84
Veterinary Medicine					3.70	22.22	37.04	37.04
Δ (Veterinary Medicine)	−100.40	−100.40	−100.40	−100.40	−83.56	37.39	223.89	187.12
Architecture	1.00		1.00	1.00	15.00	49.00	17.00	16.00
Δ (Architecture)	−77.38	−101.50	−91.57	−95.92	−32.53	205.65	48.98	24.07
Food Science	2.53	3.80	10.13	12.66	30.38	18.99	11.39	10.13
Δ (Food Science)	−40.30	−20.13	−0.95	−30.67	38.07	17.46	−0.66	−21.96

Notes: Author's calculations; highlighted faculties classified as S&T (OECD, 1995)

Table III.
Distribution of earnings by faculty (FDAR 2003)

initial earnings data into eight ordered outcomes corresponding to the salary bands presented in Figure 3. While this precludes the application of a traditional mincerian equation of earnings, an ordinal probit model readily lends itself to the analysis of ordered wage outcomes. Therefore, in the present case, the ordered initial earnings Y for an individual i are modelled against a combination of individual characteristics and employment-related variables, X.

Individual characteristics include type of education (dummies for faculty of study, facul1-10 and variable stedu, S&T faculty or otherwise), age (variable age), gender (variable gendr), years of schooling (yschool, years spent at university), award class as a proxy for ability (variable fcd, a dummy indicating first class award or masters with distinction) and a dummy for research degrees (isced). Employment-related variables include a proxy of work mobility (workmb, taking the value of one if the county of employment differed from the county of origin or study, zero otherwise), a dummy indicating whether the graduate was employed in a company operating within Ireland's innovation intensive and export-oriented clusters (ICT or biotechnology, variable cluster) as well as a set of NACE industry dummies controlling for sector-fixed effects.

Being the most recent one, the dataset for 2003 was used. Excluded from the analysis were those respondents whose occupational description was not reported or was only partially stated, leaving 5,486 valid responses. Hence, Y_i^*, the unobserved (exact) annual salary is determined by a set of X_i variables plus an error term e_i (Greene, 2003):

$$Y_i^* = X_i'\beta + e_i \tag{4.2}$$

The direction of any underlying relationships between X_i and Y_i^* is denoted by the sign of β. Although, Y_i^* is not observed, we do observe Y_i which is ordered according to the salary scales J, ($J = 1\ldots 8$). Y_i^* and Y_i are related in the following fashion:

$$\begin{aligned} &Y_i = 0 \quad \text{if } Y_i^* \le \mu_1; \quad Y_i = 1 \quad \text{if } \mu_1 < Y_i^* \le \mu_2; \quad Y_i = 2 \\ &\text{if } \mu_2 < Y_i^* \le \mu_3; \quad \ldots \quad Y_i = J \quad \text{if } Y_i^* \ge \mu_{J-1} \end{aligned} \tag{4.3}$$

where μ_J are unknown threshold parameters to be estimated along with β. Assuming $e_i \sim N(0,1)$ then the probabilities that an individual has an annual salary J can be calculated by:

$$\begin{aligned} &\text{Prob}(Y = 0|X) = \Phi(-X'\beta), \quad \text{Prob}(Y = 1|X) = \Phi(\mu_1 - X'\beta) - \Phi(-X'\beta), \\ &\text{Prob}(Y = 2|X) = \Phi(\mu_2 - X'\beta) - \Phi(\mu_1 - X'\beta), \quad \ldots \\ &\text{Prob}(Y = J|X) = 1 - \Phi(\mu_{J-1} - X'\beta) \end{aligned} \tag{4.4}$$

Given the multiple, non-uniform levels of the dependent variable, the estimated coefficients have no straightforward interpretation. Insofar as the values of the dependent are ordered though, the signs of the coefficient estimates do give away the overall direction of the (probabilistic) relationship.

Three model specifications are reported here (Table IV), a narrowed-down version with the bare essentials suggested by theory (Model 1), a second saturated version controlling for sector-fixed effects (Model 2) and a third parsimonious variation (Model 3).

$n = 5{,}486$	Model 1 Log likelihood = −9,916.4 LR $\chi^2(16) = 1{,}745.99$ $(P = 0)$ McFadden $R^2 = 0.0809$		Model 2 Log likelihood = −9,798.43 LR $\chi^2(29) = 1{,}981.95$ $(P = 0)$ McFadden $R^2 = 0.0918$		Model 3 Log likelihood = −9,800.92 LR $\chi^2(21) = 1{,}976.96$ $(P = 0)$ McFadden $R^2 = 0.0916$	
	Coef.	SE	Coef.	SE	Coef	SE
facul2	−0.09923*	0.052099	−0.21801***	0.055401	−0.25685***	0.046847
facul3	0.233114***	0.038145	0.261022***	0.043199	0.24907***	0.041141
facul4	0.531999***	0.08059	0.111617	0.094692		
facul5	0.335347***	0.058788	0.227575***	0.063617	0.196058***	0.055533
facul6	−0.47281***	0.101103	−0.38804***	0.103542	−0.40694***	0.102531
facul7	−0.18767	0.13155	−0.24114*	0.135483	−0.29742**	0.131516
facul8	1.156524***	0.214948	1.387903***	0.220955	1.333619***	0.21766
facul9	0.291673**	0.116051	0.059601	0.126629		
facul10	0.061659	0.120664	0.076613	0.125627		
Yschool	0.360551***	0.022175	0.390009***	0.022677	0.414155***	0.015814
Gendr	−0.13669***	0.030427	−0.13538***	0.030856	−0.1344***	0.030504
Age	0.039187***	0.003015	0.038713***	0.003029	0.037635***	0.002957
Fcd	0.173061***	0.043648	0.218039***	0.04393	0.209774***	0.043713
Workmb	0.283466***	0.031814	0.273086***	0.031992	0.270963***	0.031928
co_db	0.287239***	0.029353	0.25622***	0.030287	0.253186***	0.0301
Cluster	0.179408***	0.041286	0.386754***	0.05325	0.385633***	0.052695
isced[c]						
NACE_ab			−0.46568**	0.21562	−0.46601**	0.206045
NACE_c			−0.07328	0.195211		
NACE_d			−0.38895***	0.090787	−0.38551***	0.062094
NACE_e			0.052747	0.200261		
NACE_f			0.021621	0.111523		
NACE_g			−0.59183***	0.09698	−0.59273***	0.073707
NACE_h			−0.68023***	0.102437	−0.6787***	0.080332
NACE_I			−0.33801***	0.108188	−0.33958***	0.087237
NACE_j			−0.22647***	0.083836	−0.22587***	0.054399
NACE_k			−0.63048***	0.084489	−0.6296***	0.054226
NACE_l			−0.12608	0.108497		
NACE_m			−0.55902***	0.07649	−0.5739***	0.044205
NACE_ot			0.007836	0.083667		
$\mu 1$	0.739795	0.099353	0.403277	0.122535	0.446713	0.101019
$\mu 2$	1.141219	0.097846	0.813489	0.121361	0.856919	0.099506
$\mu 3$	1.665755	0.097485	1.354407	0.121039	1.397478	0.099051
$\mu 4$	2.256873	0.098195	1.962529	0.121476	2.004801	0.099634
$\mu 5$	2.923345	0.099867	2.644625	0.122576	2.685681	0.101183
$\mu 6$	3.489766	0.101933	3.223646	0.123978	3.263719	0.103169
$\mu 7$	4.046298	0.104665	3.791419	0.12617	3.832056	0.105726

Notes: Significance at: *0.1, **0.05 and ***0.01 levels; the ordinal logit estimation method was also tried and although the assumption of parallel lines across equations did not hold (Hosmer and Lemeshow, 2000) results were qualitatively identical; interaction terms for stedu*fcd, stedu*yschool, stedu*gendr, stedu*cluster and stedu*workmb were attempted but were not found to be statistically significant; [c]isced was omitted from all equations due to severe multicollinearity with yschool

Table IV.
Ordinal probits of earnings

Qualitatively the results in all three models are the same; hence the interpretation that follows is based on the parsimonious specification (Model 3).

Table IV shows that the positive relationship between an engineering (facul5) education and the likelihood of a higher salary is maintained, even after controlling for other factors. However, controlling for factors, a graduate of the Faculty of Science (facul2) is likely to secure a lower salary. Among the graduates' characteristics, higher values in the variables for years of tertiary schooling and age (yschool, age) exerted a positive influence on the probability of being at a higher wage band. Possessing a first class degree or another educational distinction is also likely to lead to higher initial earnings. However, the negative sign in the variable for gender (gendr) implies that, *ceteris paribus*, women were more likely to enter employment in a lower wage band. This is in agreement with the findings of Callan and Harmon (1999) and Denny and Harmon (2000), as is the positive effect associated with posts situated in county Dublin (co_db). Being employed in a company operating in one of Ireland's innovative clusters (cluster) also has a positive effect on salary. Interestingly, those who were willing to relocate away from either their home county or their county of study (workmb) increased their likelihood of securing better salaries.

The magnitude of the difference between the predicted probabilities for graduates with a particular education and other graduates within a wage band j would be a measure of the relative advantage of possessing a particular education controlling for other factors. Following Borooah (1999), on the basis of the regression estimates, it may be calculated as:

$$\Delta\% = \left(\frac{P_{\text{educ}} - P_{\text{other}}}{P_{\text{total}}}\right) \cdot 100 \qquad (4.5)$$

Assuming that the model specification exhausts the set of relevant factors affecting the probability of being in one of J salary bands, differences between P_{educ} and P_{other} are entirely the effect of education, because that is the only factor that differed between the two sets of calculations (Borooah, 1999). Table V presents the probabilities (unadjusted as well as those predicted after controlling for other factors) of being in each wage band for graduates from the Faculty of Engineering versus other graduates.

After controlling for other factors, engineering graduates are approximately 20 per cent less likely to be found in one of the three lower wage bands. It is clear from Table V that engineering graduates possess a profound relative advantage; *ceteris paribus*, not only are they less likely to be found in lower wage bands, but also the magnitude of the advantage increases to just over 27 per cent for salaries above €33,000 ($J = 8$).

Table V. Probability of entering employment into wage band j: engineering graduates

	Unadjusted sample proportions			Predicted by model		
Wage band j	Engineering	Other	Total	Engineering	Other	Δ
1	0.82	4.62	4.2	1.34	2.18	−20.00
2	1.10	5.18	4.7	2.22	3.21	−21.06
3	3.84	10.99	10.2	6.76	8.89	−20.88
4	11.66	18.95	18.2	15.26	17.98	−14.95
5	22.36	22.04	22.1	25.4	26.46	−4.80
6	32.37	14.23	16.2	21.68	20.05	10.06
7	13.44	11.23	11.5	15.26	12.65	22.70
8	14.40	12.76	12.9	12.09	8.58	27.21

By sharp contrast, after controlling for other factors, graduates from the Faculty of Science appear to face an almost commensurate relative disadvantage (Table VI). The disadvantage of such graduates is particularly high at lower wage bands (where they are almost 37 per cent more likely to be found). This does not, of course, mean that science graduates earn overall less than other graduates, but rather that they earn less given their investment in education (in terms of years spent studying), the industrial sectors they work in and their individual characteristics.

5. Conclusion

Analysis of the FDAR data for three consecutive years has revealed that graduates from faculties with a core S&T element have consistently enjoyed a wider occupational domain. This is a strong indication that such graduates possess skills that are needed across a wide range of occupations, though the precise reason for this remains unclear. It may well be that it is the result of technological advancement or it may be that S&T skills are "by nature" more diffuse in their realm of application. Alternatively, this difference may be partly related to the difficulties[11] that some S&T graduates face in securing appropriate employment straight after graduation. A comparative look at earlier data could contribute towards settling this.

At the same time, as also seen previously (Borghans *et al.*, 1997), professional options narrow down substantially for awards of higher levels. The difference in the occupational domain of S&T versus other graduates is hardly noticeable though when research-oriented degrees are considered. In addition to a wider educational domain (when seen collectively), S&T education tends to be associated with higher initial earnings. A rather more mixed picture appears however when different faculties are considered; while collectively S&T faculties appear to possess a relative earnings advantage, wide variations exist within the S&T group. After controlling for other factors, ordinal probit regression estimates based on the 2003 survey show that engineering education was positively associated with the probability of being in a higher wage band. However, rather unexpectedly, graduates from the Faculty of Science are not remunerated favourably in relation to their investment in education and other factors. Why exactly this should be the case is not immediately obvious. For instance, it could be (wholly or in part) related to the periods of low-paid professional training that often follow a degree in science, indicate a possible lack of demand for "abstract" scientific skills or perhaps be suggestive of over-supply of science graduates. The entrepreneurial orientation of some engineering graduates in particular

	Unadjusted sample proportions			Predicted by model		
Wage band j	Science	Other	Total	Science	Other	Δ
1	2.60	4.53	4.2	3.45	1.9	36.90
2	3.32	5.02	4.7	4.5	2.89	34.26
3	11.21	10.03	10.2	11.32	8.24	30.20
4	18.83	18.03	18.2	20.44	17.2	17.80
5	25.38	21.42	22.1	26.57	26.25	1.45
6	17.49	15.94	16.2	17.81	20.59	−17.16
7	9.24	11.91	11.5	10.05	13.41	−29.22
8	11.93	13.13	12.9	5.86	9.52	−28.37

Table VI. Probability of entering employment into wage band j: science graduates (variable facul2) may also be an important consideration. Further research may seek a resolute answer by examining the destinations of science graduates qualitatively and doing so at various points in their careers.

Regression estimates also suggest that labour mobility and employment in ICT or biotechnology firms are also more highly rewarded. These results point to a dynamic labour market, conducive to the knowledge flows envisaged in a stylised national innovation system (Lundvall, 1992). They also signal that Ireland's innovation-intensive sectoral clusters (ICT and biotechnology) can afford to pay premia for skilled graduates – an observation that is in itself open to multiple interpretations.

The observed labour market experiences probably owe a great deal to non-permanent skills shortages. It is also possible though, that fundamental structural changes are responsible, at least in part, for this observation. In future, it would be purposeful to check whether the above persist for non-recent graduates and perform an in-depth analysis of time-series trends.

The findings are of direct relevance to education policies that aim to increase the take up of S&T subjects (OECD, 2000; Gago *et al.*, 2004). Assuming that there are social gains to be had from further increases in the numbers of S&T graduates, their unobstructed supply hinges on the presence of proportionate private returns to such skills. The (for the most part) considerable private returns to S&T skills identified here, hint that market leverage is strong. Moreover, to the extent that an economy displays a preference for specific skills, it may contribute to inequality among population subgroups that are less likely to possess them. The potential for aggrevating the already existing gender disparities in particular is strong, given that women are less likely to take up S&T subjects.

Although the study's empirical findings are specific to Ireland, they do hold broader interest internationally. First, by highlighting the relatively lower earnings of recent science graduates in Ireland, they bring into question the current preoccupation with the active management of the supply of S&T skills and suggest that a closer look at the demand for such skills may be warranted. Second, by showing that the returns to different types of education vary both within the broad S&T group and between S&T and other types of education, they highlight the value of context-specific analyses and open up opportunities for further research on a matter of major policy relevance internationally.

Notes

1. Honohan and Walsh (2002) present a balanced view of the Irish growth experience. For a review of developments in innovation-intensive sectors during the 1990s see Barry and Bradley (1997). Also Görg and Ruane (2000).
2. Projections of occupational needs indicate that severe labour shortages are likely to occur in the ICT and biotechnology sectors before the end of the decade (Sexton *et al.*, 2004; IAE and EI, 2005).
3. While the skills bias hypothesis makes its existence plausible in the case of Ireland, no explicit attempt is made here to link this bias with technical change.
4. Especially since cost-efficiency, a pro-FDI tax regime and EU membership no longer distinguish Ireland from other European economies.
5. This limits the scope of the HEA's FDAR Survey (and by extension the present study) to university graduates only.

6. According to Eurostat data, (CEC, 2004) S&T graduates accounted for 32.1, 34.5 and 31.9 per cent of all Irish tertiary graduates in 1998, 2000 and 2001, respectively. For the same years, the numbers of S&T tertiary graduates per thousand inhabitants was 22.4, 23.2 and 21.7.
7. Although response rates for the given surveys were high (it is worth remembering that these are percentages of the population total graduating each year), as an added precaution, an attempt was made to establish the presence or otherwise of non-response bias. A comparison of response rates across different population sub-groups (not reported here, but is available from the author upon request), indicated no substantial evidence of systemic non-response bias.
8. Assuming for a moment that persons with educational background i are occupied in n occupations, and are equally spread among those occupations (so that $f_{ij} = 1/n$), then $K_i = n$. In other words, the index K_i will also represent the number of occupations corresponding to individuals with education i. Even if not all fractions f_{ij} are equal, the index K_i will still reflect the number of occupations open to individuals of educational background i, with the drawback of assigning the same weight to all fractions f_{ij} regardless of their size. The above limitation is not restrictive for the present analysis; if at least one person with education i is employed in occupation j, this is evidence that this occupational outcome is open to individuals educated likewise.
9. The HEA uses its own occupational classification reflecting Irish economic reality. It accounts for a total of 125 distinct occupations, 58 of which have been classified here as S&T according to the guidelines set in the Canberra Manual (OECD, 1995).
10. For an exposition, see Barry (2005).
11. A rough indication of such difficulties can be seen in the differences between the unemployment rates of S&T versus non-S&T graduates; in 2001, 2002, and 2003 unemployment rates for S&T graduates were 5.7, 5.1 and 4.3 per cent as opposed to 3.1, 3.7 and 3.6 per cent for other graduates, respectively.

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Appendix 1

Variable name	Description	Values
facul_1-10	HEA faculty of study; proxy of "educational component". Coding: 1 – Arts, Social Science and Humanities 2 – Science 3 – Commerce and Business Studies 4 –- Medicine, Dentistry and Paramedical Studies 5 – Engineering 6 – Law 7 – Agriculture 8 – Veterinary Medicine 9 – Architecture 10 – Food Science & Technology	0 – not graduated from faculty 1 – graduated from faculty
Stedu	S&T degree defined as resulting from studies in one the following HEA faculties (as per OECD, 1995): Science; Medicine, Dentistry and Paramedical Studies; Engineering; Agriculture; Veterinary Medicine; Architecture; Food Science and Technology	0 – non-S&T degree 1 – S&T degree
Stemp	S&T employment defined as jobs in the following HRST occupations (as per OECD, 1995, narrow definition; ISCO88 Classifications): "Professionals" (ISCO Major Group 2), "Technicians and Associate Professionals" (ISCO Major Group 3), other S&T occupations (ISCO Major Groups 4-9) but excluding "Legislators, Senior Officials and Managers" (ISCO Major Group 1)	0 – employed in non-S&T 1 – employed in S&T
Socec_1-12	Socioeconomic Classification dummy variables – as reported by students upon registration. Coding: 1 – Farmers 2 – Other Agr. and Fishermen 3 – Higher Professional 4 – Lower Professional 5 – Employers and Managers 6 – Salaried Employees 7 – Intermediate Non-Manual Workers 8 – Other Non-Manual Workers 9 – Skilled Manual Workers 10 – Semi-Skilled Manual Workers 11 – Unskilled Manual Workers 12 – Not Available	0 – not belonging to classification 1 – belonging to classification
Fcd	First class award or distinction. Proxy of ability, as signalled by the graduate's award class	0 – Pass, Third Class Honours, Second Class Honours Grade 2, Second Class Honours, Second Class Honours Grade 1 1 – (Masters Degree) Recommended, First Class Honours, MRIT (Certificate/Diploma) with distinction
Isced	Classification of awards according to ISCED'97. An indication of the degree's relevance to occupations requiring innovative skills (e.g. R&D) (UNESCO, 1997)	0 – ISCED 5A (research preparatory): bachelors degree/PGD/masters degree taught and qualifier 1 – ISCED 6 (research degrees): MPhil/PhD
Yschool	Years of schooling at tertiary education. (Inferred on the basis of the typical duration of awards in each faculty)	3 – BA (Arts, Commerce, Law) 4 – BSc, BEng (Science, Engineering, Agriculture, Food Science) MA, PG/HDip (Arts, Commerce, Law) 5 – BA (Veterinary Medicine), BSc (Architecture), MSc, PG/HDip (Science, Engineering, Agriculture, Food Science), MRes (Arts, Commerce, Law)

(continued)

Table AI.
The study's variables

Variable name	Description	Values
		6 – BA (Medicine), MSc (Veterinary Medicine), MSc, PG/HDip (Architecture), MRes (Science, Engineering, Agriculture, Food Science) 7 – MSc, PG/HDip (Medicine), PhD (Arts, Commerce, Law), MRes (Veterinary Medicine, Architecture) 8 – PhD (Science, Engineering, Agriculture, Veterinary Medicine, Architecture, Food Science), MRes (Medicine) 9 – PhD (Medicine)
Salr	Annual salary, on April of the year following graduation	1 – up to € 8,999 2 – € 9,000 – €12,999 3 – €13,000 – €16,999 4 – €17,000 – €20,999 5 – €21,000 – €24,999 6 – €25,000 – €28,999 7 – €29,000 – €32,999 8 – €33,000 +
sc_1-14	Sector-fixed effect; 14 dummy variables. Industrial sector of employment, NACE classification coding: 1 – NACE Sections A&B: Agr. Forestry and Fishing 2 – NACE Section C: Mining and Quarrying 3 – NACE Section D: Manufacturing 4 – NACE Section E: Electricity, Gas and Water Supply 5 – NACE Section F: Construction 6 – NACE Section G: Wholesale and Retail Trade 7 – NACE Section H: Hotels and Restaurants 8 – NACE Section I: Transport, Storage and Communications 9 – NACE Section J: Financial Intermediation 10 – NACE Section K: Real Estate, Renting and Business Activities 11 – NACE Section L: Public Admin. and Defence 12 – NACE Section M: Education 13 – NACE N&O: Health and Social 14 – Other	0 – not employed in sector 1 – employed in sector
Cluster	Employment in ICT or biotechnology sectoral clusters. Includes companies operating in the following sectors: Computer and electronic equipment, Office Machinery, Instrument Engineering (incl. healthcare equipment), Pharmaceuticals, perfumery and toilet preparations, Call Centres and Shared Services Facilities, Other Business Services (incl. Management and IT Consulting), Consultant Engineering and Architectural Services, Computing and Software Applications	0 – No ICT/Biotech cluster 1 – ICT/Biotech cluster
Age	Age of respondents (in years) at the time of the survey	Continuous variable
Gendr	Gender	0 – Male 1 – Female
co_db	Destination company location, NUTS3 region	0 – Other 1 – Dublin
Workmb	Proxy of geographic mobility in the school to work transition	0 – if orig_nuts3 or inst_loc = locat_nuts3 1 – all others

(*continued*)

Table AI.

Variable name	Description	Values
Orig_nuts3	Respondent's origin (before further/higher study), NUTS3 region	1 – Border 2 – Midland 3 – West 4 – Dublin 5 – Mid-East 6 – Mid-West 7 – South-East 8 – South-West 9 – Other/Non-Specified/Abroad
locat_nuts3	Destination company location, NUTS3 region	(as in orig_nuts3)
Inst_loc	University locations, NUTS3 region	(as in orig_nuts3)

Table AI.

Appendix 2

Variable	*N*	Mean	SD	Minimum	Maximum
Salr	6,750	4.082667	1.862429	0	7
stemp	11,249	0.359765	0.479953	0	1
stedu	18,425	0.36711	0.48203	0	1
facul1	18,425	0.35251	0.477765	0	1
facul2	18,425	0.180407	0.384537	0	1
facul3	18,425	0.244016	0.429514	0	1
facul4	18,425	0.054003	0.226029	0	1
facul5	18,425	0.09943	0.299247	0	1
facul6	18,425	0.036364	0.187198	0	1
facul6	18,425	0.036364	0.187198	0	1
facul7	18,425	0.012049	0.109107	0	1
facul8	18,425	0.003148	0.056019	0	1
facul9	18,425	0.009824	0.098629	0	1
facul10	18,425	0.00825	0.090455	0	1
yschool	18,425	3.839023	1.033591	3	9
isced	18,425	0.029199	0.16837	0	1
gendr	18,425	0.583392	0.49301	0	1
age	16,569	24.44215	5.613576	20	75
fcd	18,425	0.120489	0.325541	0	1
workmb	18,425	0.554518	0.497032	0	1
co_db	18,425	0.26947	0.4437	0	1
cluster	18,425	0.100081	0.300117	0	1
NACE_ab	18,425	0.004016	0.063249	0	1
NACE_c	18,425	0.004016	0.063249	0	1
NACE_d	18,425	0.070122	0.25536	0	1
NACE_e	18,425	0.002822	0.053051	0	1
NACE_f	18,425	0.020787	0.142674	0	1
NACE_g	18,425	0.031153	0.173737	0	1
NACE_h	18,425	0.024695	0.155197	0	1
NACE_i	18,425	0.018616	0.135168	0	1
NACE_j	18,425	0.069579	0.254444	0	1
NACE_k	18,425	0.115278	0.319366	0	1
NACE_l	18,425	0.019702	0.138976	0	1
NACE_m	18,425	0.108874	0.311489	0	1
NACE_no	18,425	0.02247	0.148209	0	1
NACE_ot	18,425	0.48787	0.499866	0	1

Table AII.
Descriptive statistics, FDAR 2003

About the author

Dimitrios Pontikakis graduated from Northumbria University with a BA in Politics and Economics and a PhD in Economics. His main research interests revolve around the broad area of the economics of technological change, approaching the subject from an industrial, labour/education and political economy perspective. Prior work investigated theoretical and empirical aspects of innovation systems. Currently at the Institute for Prospective Technological Studies (DG Joint Research Centre, European Commission), his work focuses on the economic analysis of the European Research Area. Dimitrios Pontikakis can be contacted at: dimitrios.pontikakis@ec.europa.eu